Evaluation of Vehicle Technology Benefits on Real World Drive Cycles Using Regional Transportation System Model

RAM VIJAYAGOPAL, DOMINIK KARBOWSKI, VADIM SOKOLOV
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Project ID # VS185

Project Overview

Timeline	Barriers
• Start date : Sep 2015 • End date : Aug 2016 • Percent complete : 90%	• Computational models, design and simulation methodologies (E). • Constant advances in technology (F) http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/vt_mypp_2011-2015.pdf
Budget	**Partners**

• FY15 Funding : $400K
• FY16 Funding : $0
	• OEMs via USDRIVE
	• ORNL (MA3T)
	• Argonne
	  • Vehicle Technology Evaluation
	  • POLARIS
	  • BaSce

Relevance

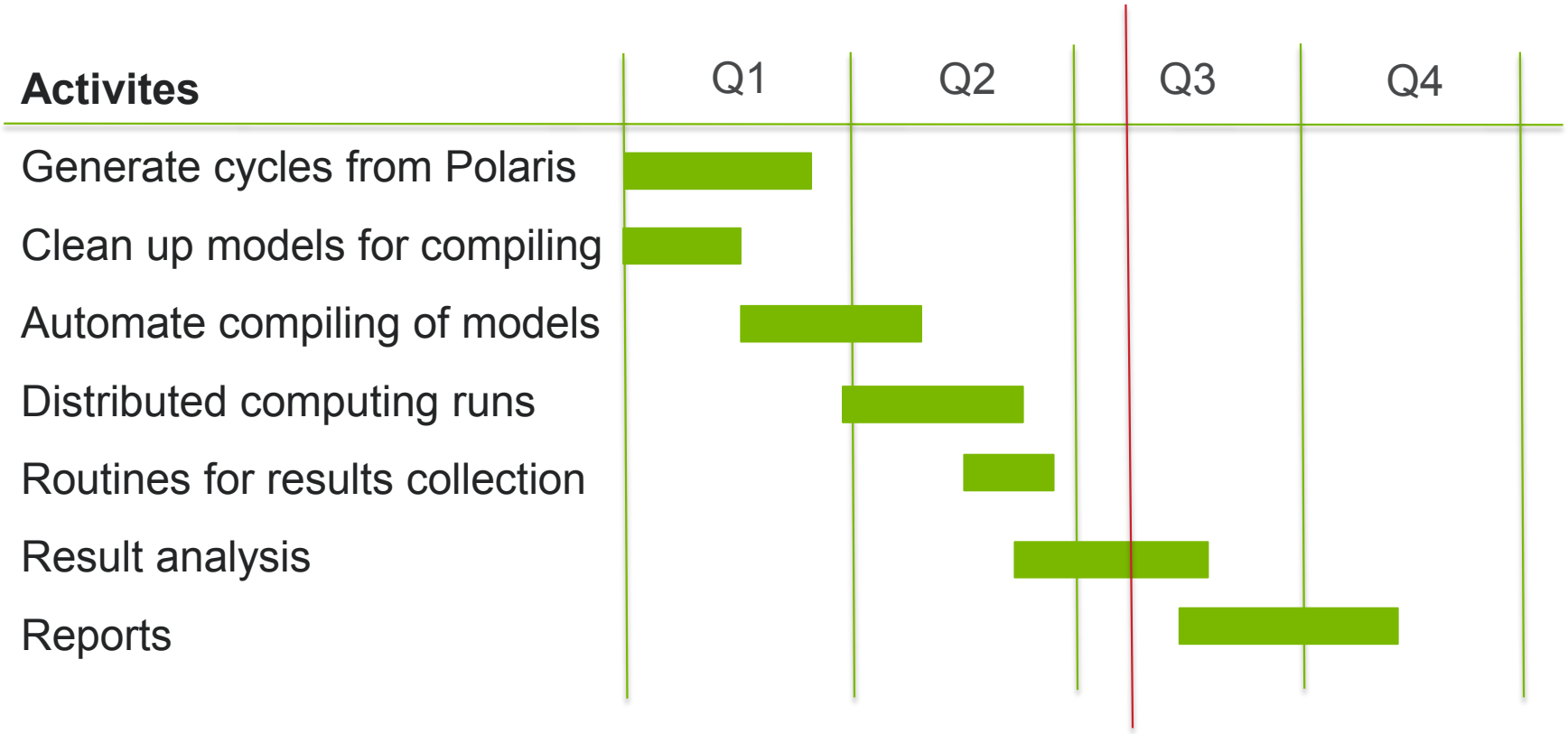
Quantify the Impact of New Technologies on Real World Driving Conditions Compared to Standard Cycles

Objective : Evaluate VTO Technology Benefits over Real World Drive Cycles (RWDC)

Key questions to be addressed:

- How do 'VTO Tech. Benefits' compare between standard test procedures (BaSce process) and real world driving scenarios?
- How to simulate many vehicles over thousands of cycles?
- Can synthetic drive cycles be used for this analysis?
- What are the key parameters to be evaluated?
- What are the sensitivity of the technologies to the choice of real world cycles

Milestones

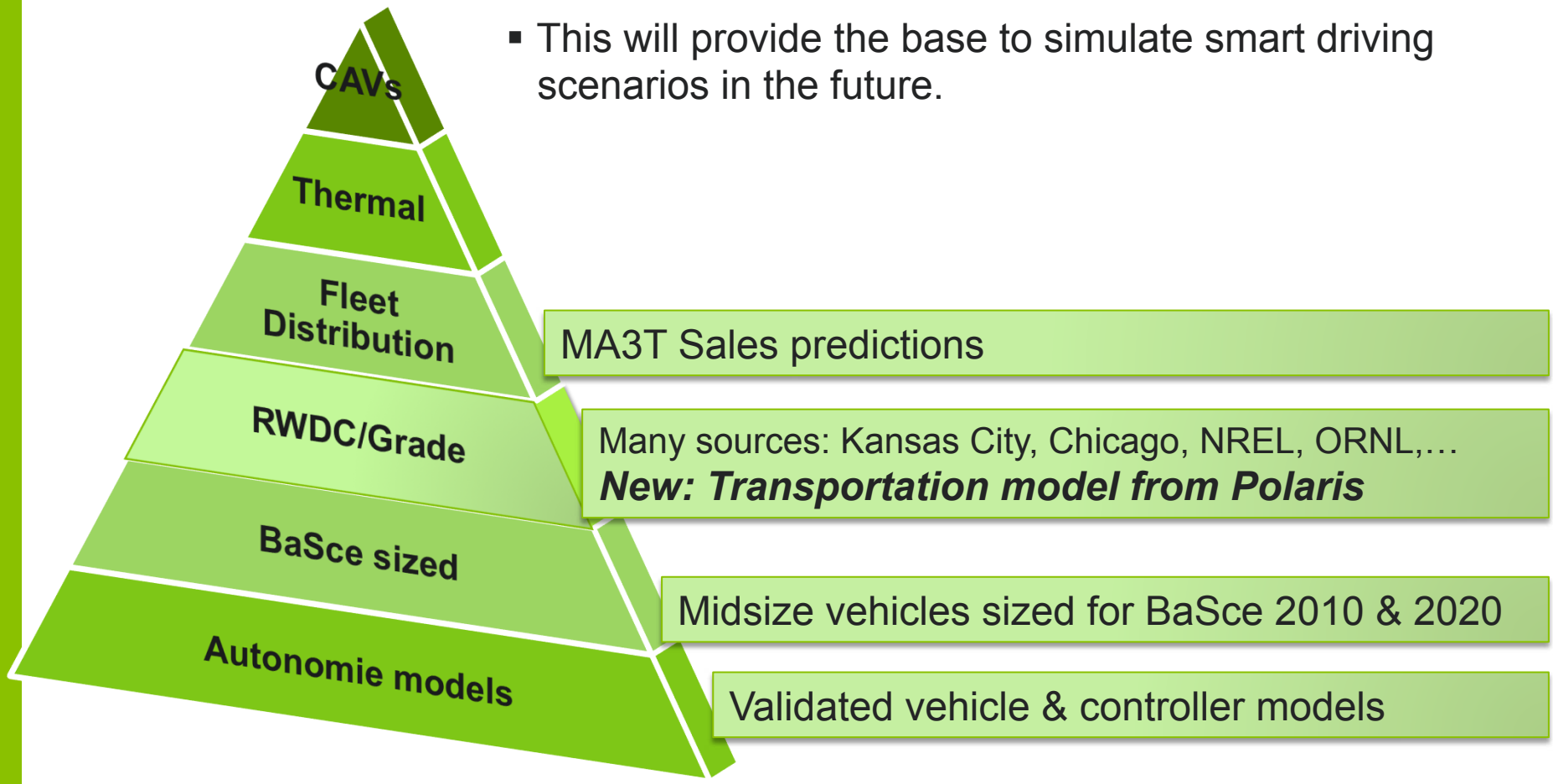


Preliminary results are available now.
Completion of analysis and reports are expected by end of FY16

Approach

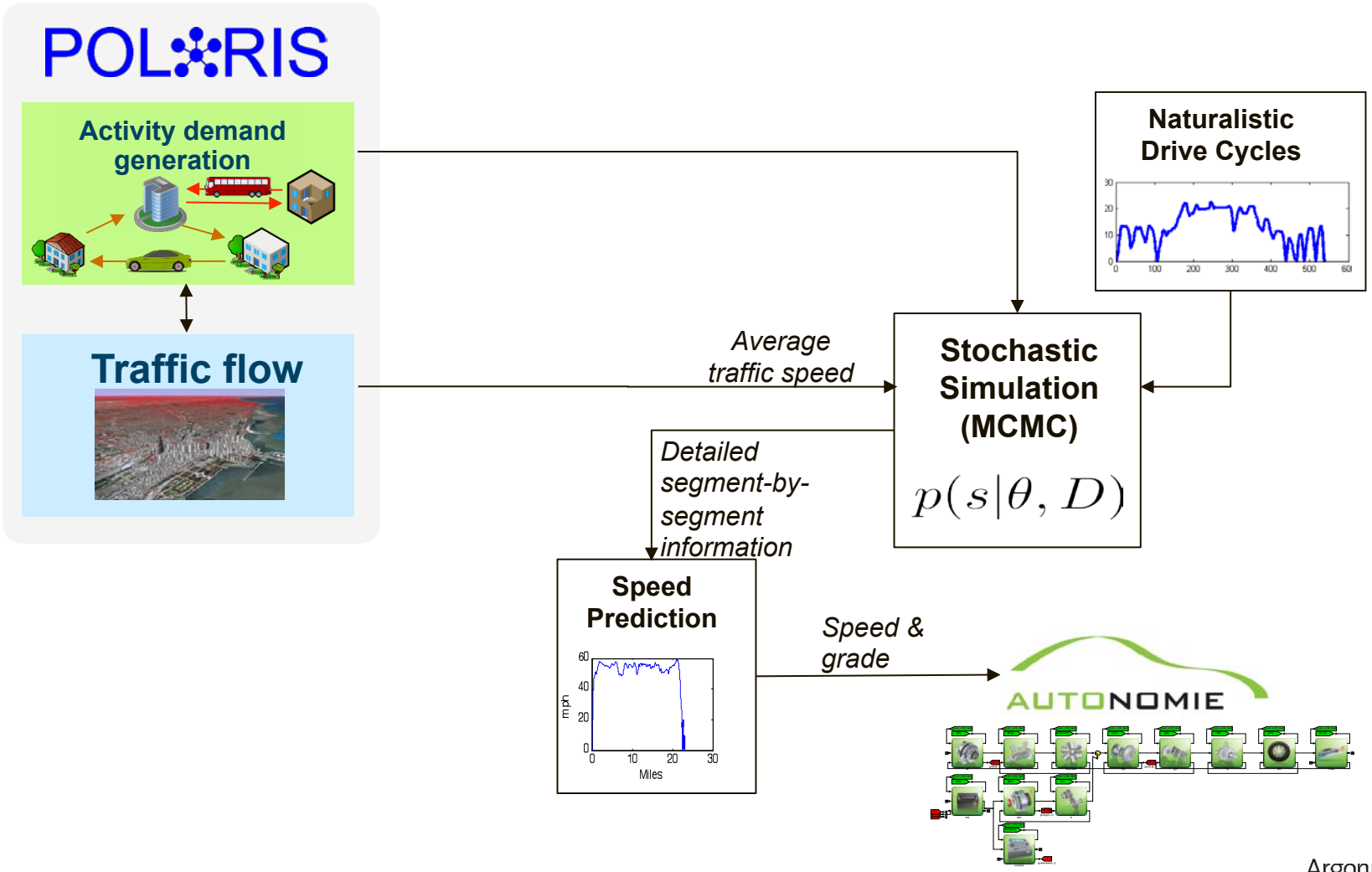
Integrate Existing Tools in a Coherent Workflow

- Present effort is to use synthetic cycles from Polaris.
- This will provide the base to simulate smart driving scenarios in the future.



Approach

Linkage between Agent-Based Transport Model (POLARIS) and High-Fidelity Vehicle Energy Model (Autonomie) to Assess Real World Driving Cycle Impact

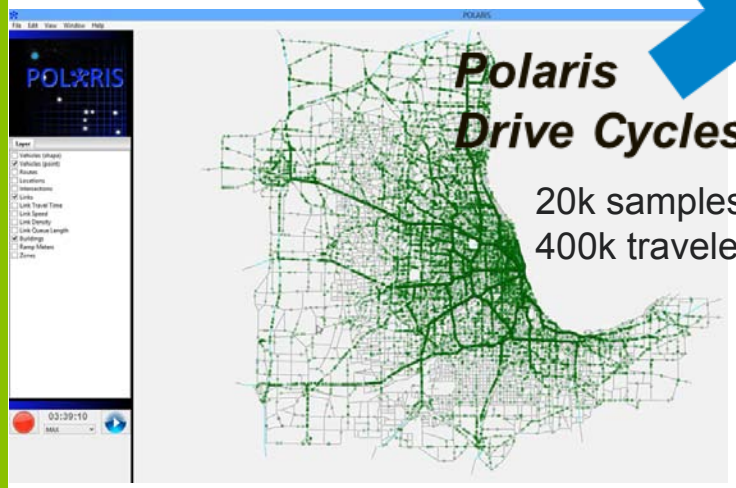


Approach

Use Large Scale Simulation Process and Vehicle Models Developed Previously (VAN023) for Evaluating Thousands of Drive Cycles

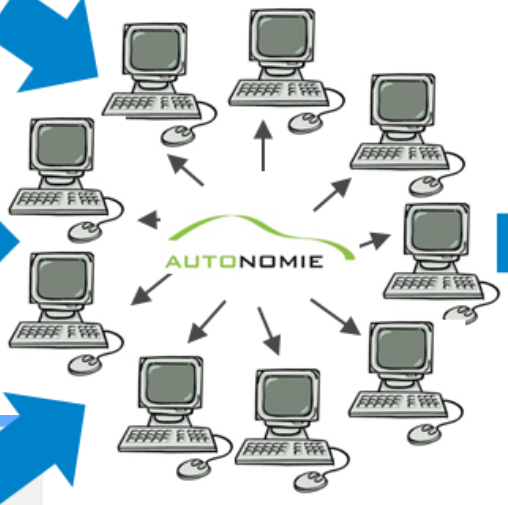
Midsize
Sim. Year
2010

Midsize
Sim. Year **2020**
(Optimistic scenario)

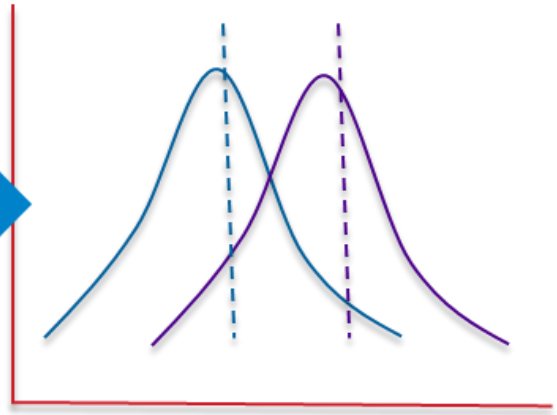


Polaris Drive Cycles

20k samples from
400k travelers



Distributed Computing



Analyze results

175 vehicles x 2 time frames x 20000 cycles = 7 million simulations

Technical Accomplishment

Accelerated Simulation Time

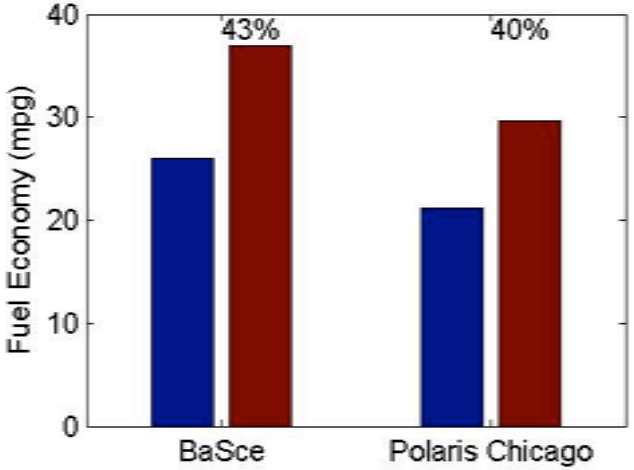
Longer initial setup vs. faster run time

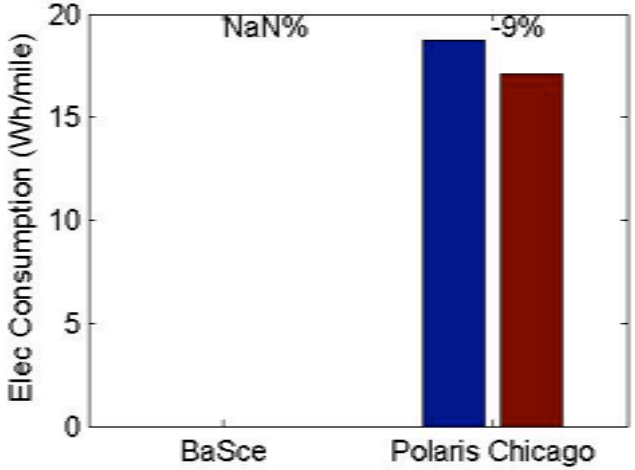
- About 100x faster simulations
  - Compiled models can evaluate a day's driving in 4-5 seconds.
- Tunable input parameters & signal logging
  - Predetermined before compiling the model
- Basic post-processing capabilities
  - Based on the signals that are recorded.
- A step towards reducing dependence on Matlab.
  - Models may be compiled to run without Matlab
- Upfront work in ensuring model correctness

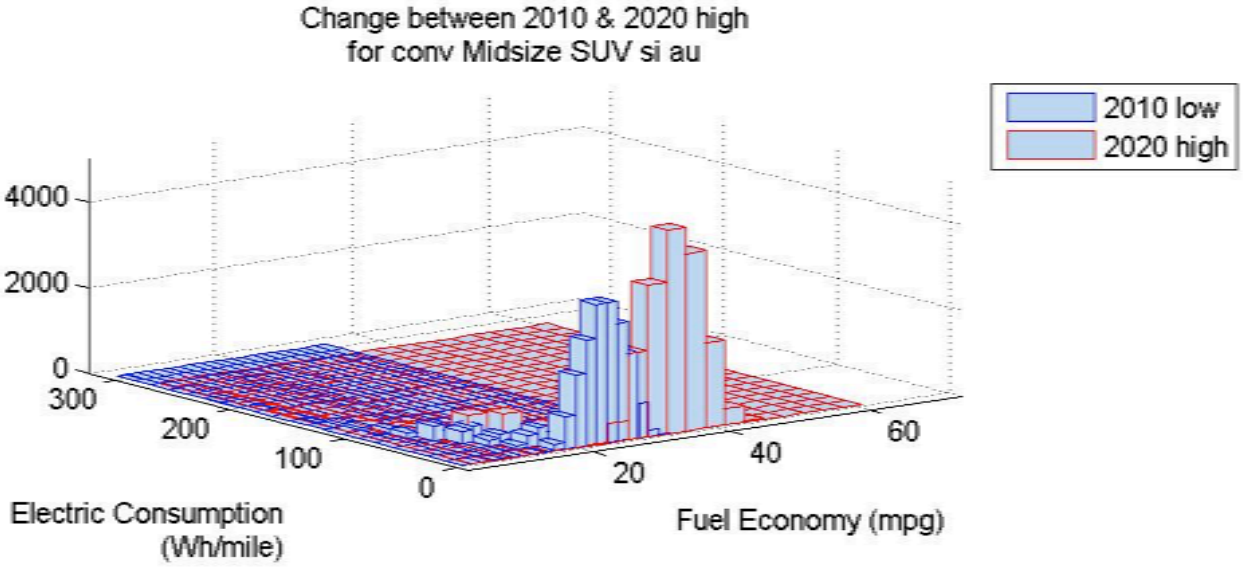
=> The new process will be reused when simulating few vehicles for a large number of scenarios

Technical Accomplishment

Conventional Midsize SUV Results

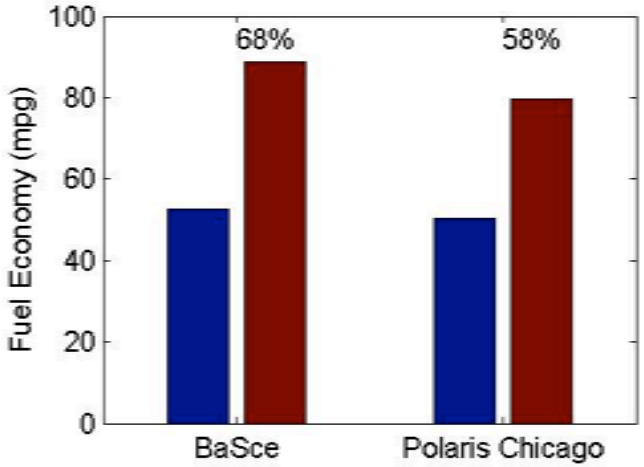


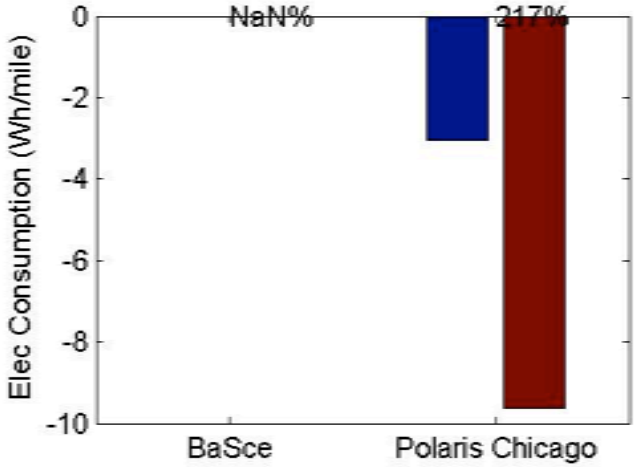


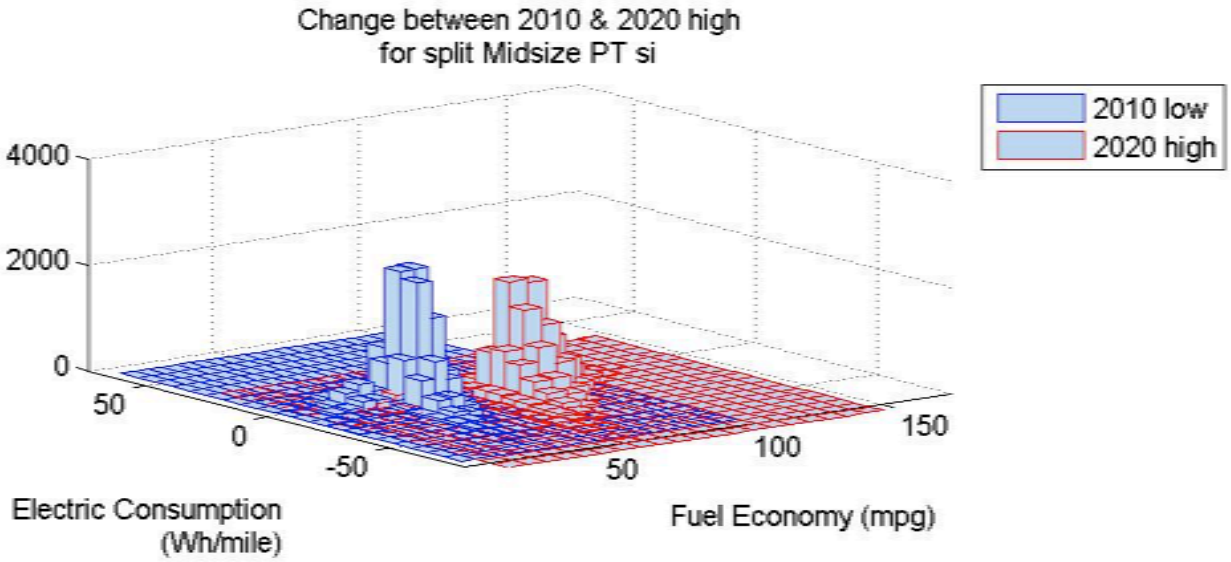


Technical Accomplishment

Power Split HEV Midsize Results







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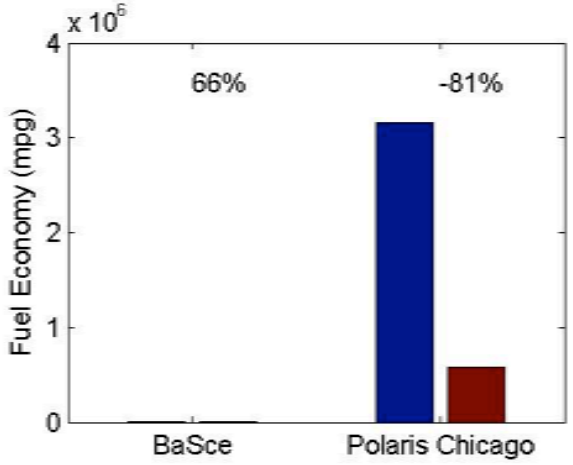
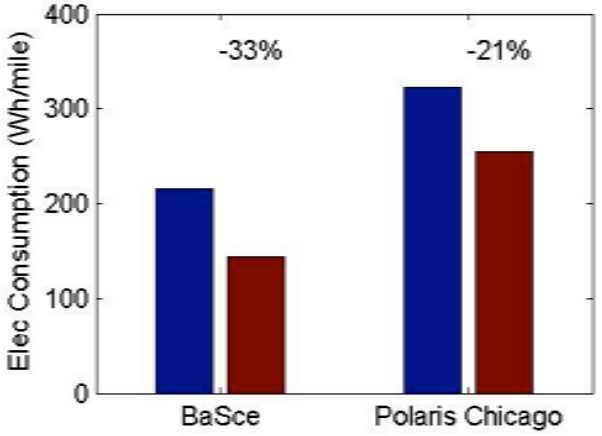
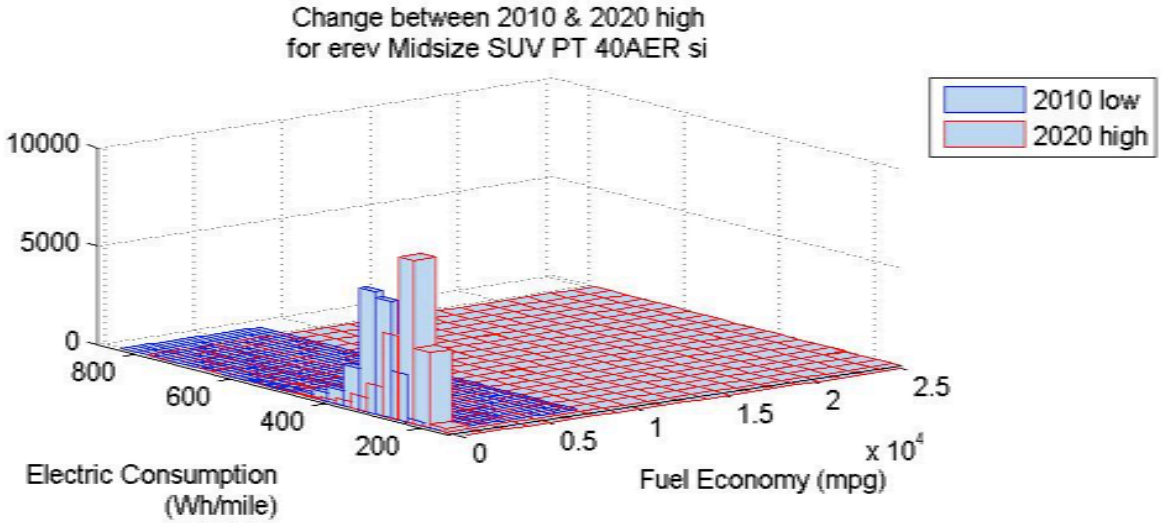
Technical Accomplishment

PHEV E-REV 40 Miles AER Midsize Results







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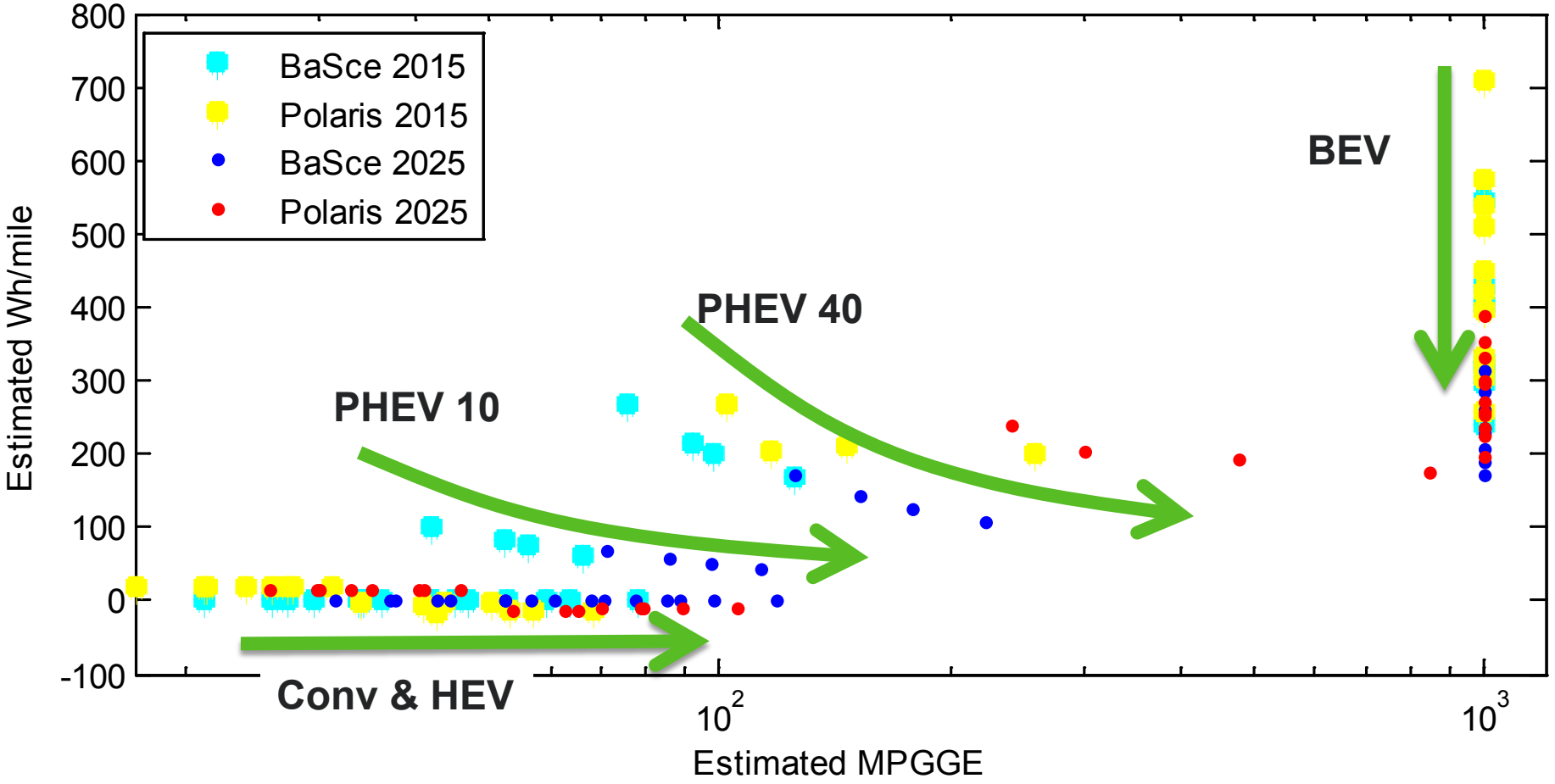
Technical Accomplishment

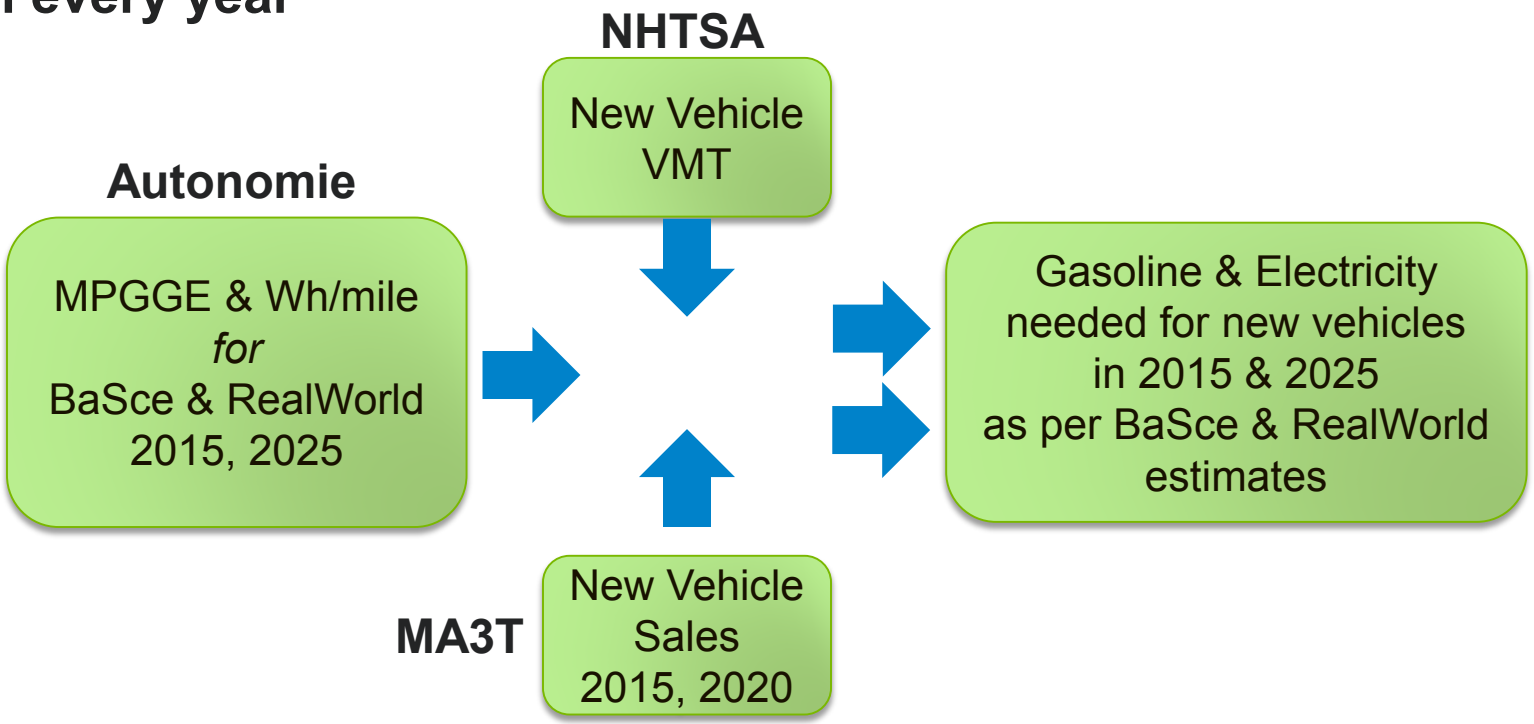
Similar Energy Consumption Trends are Observed for BaSce & RWDC Analysis Across Multiple Vehicle Classes



Technical Accomplishment

Computing fleet average from individual powertrain evaluations

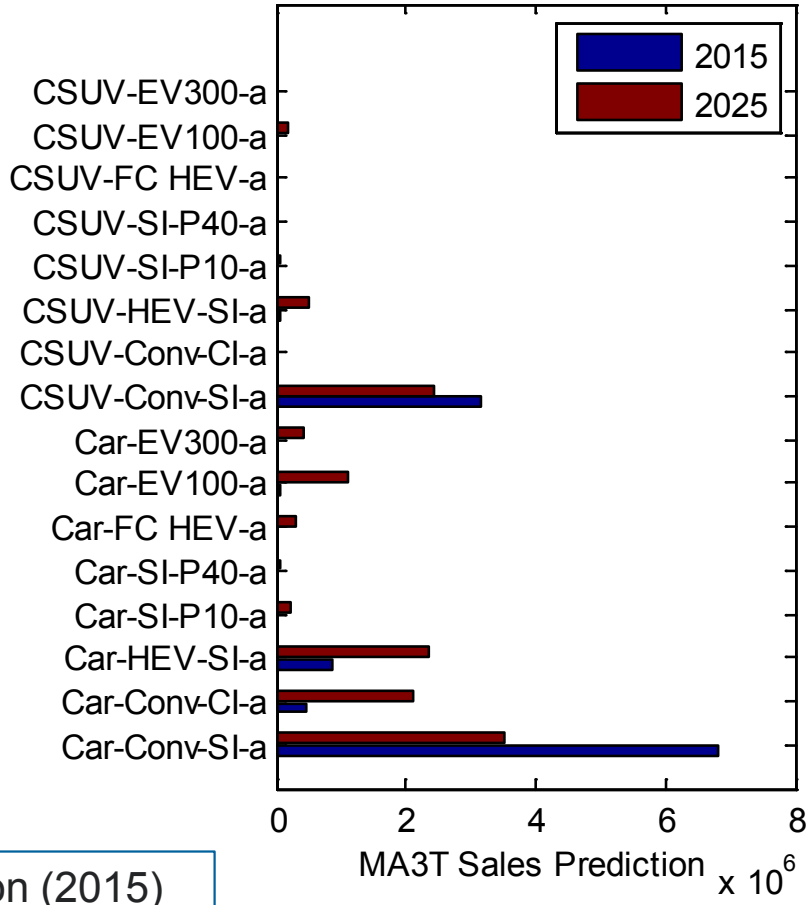
Consider the number of vehicles of each kind and how far are they driven every year

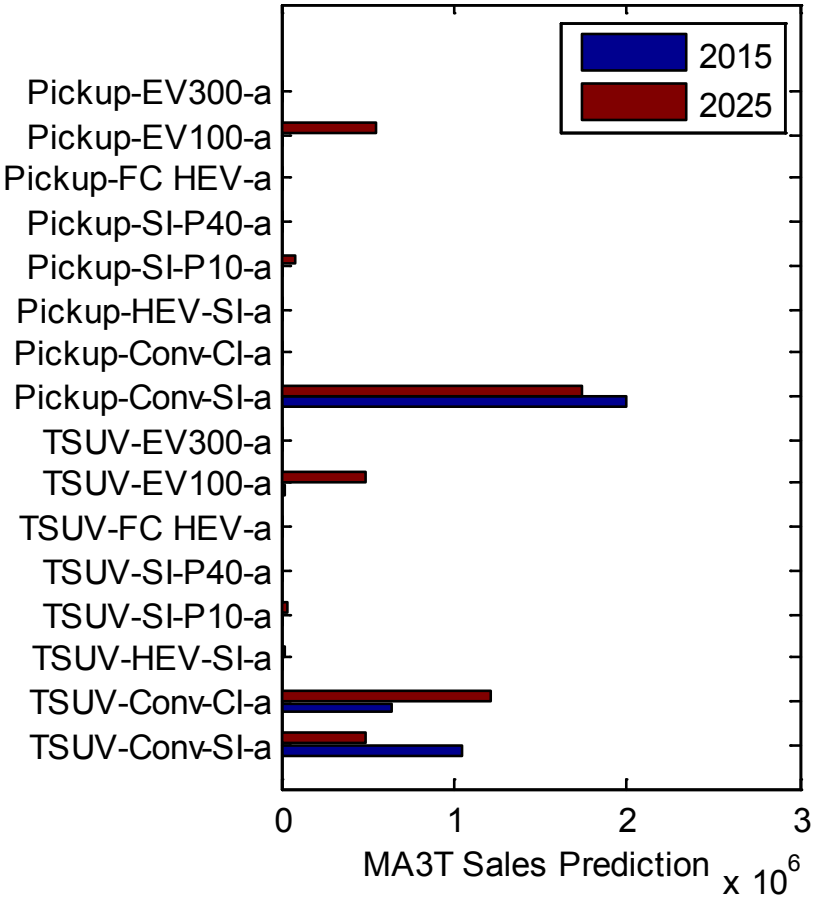


**** Only new vehicles are considered, not the entire fleet.***

Technical Accomplishment

Implemented MA3T Prediction of Sales in 2015 and 2025 for Cars and Light trucks





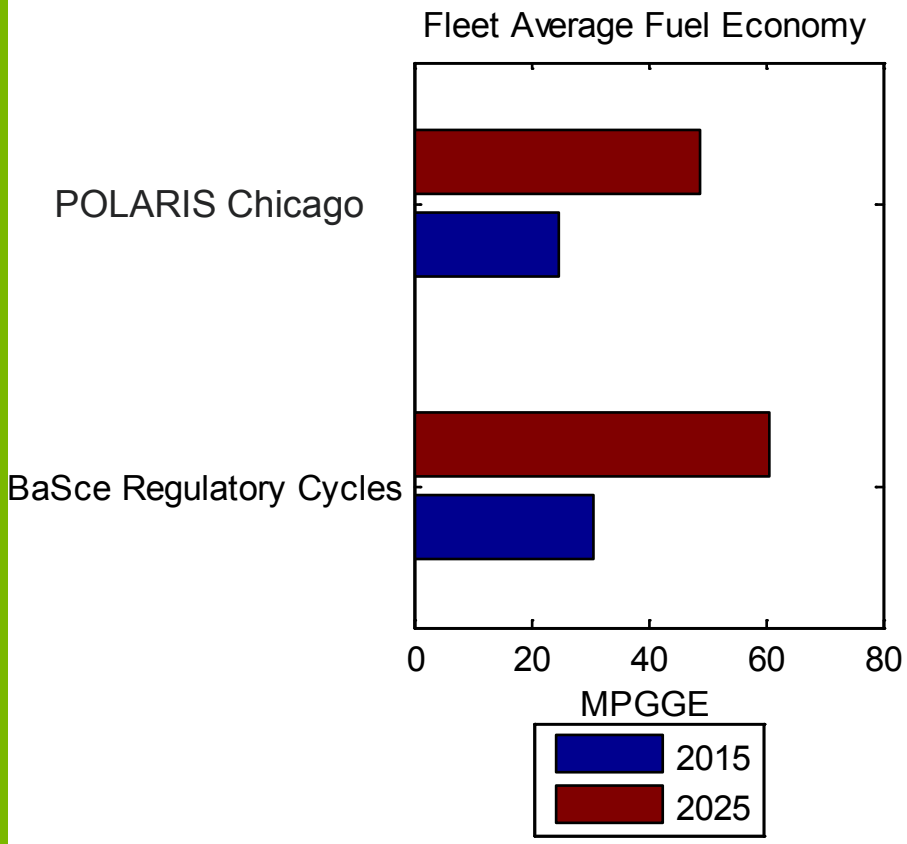
>15 million (2015)
>18 million (2025)
* Not all classes included

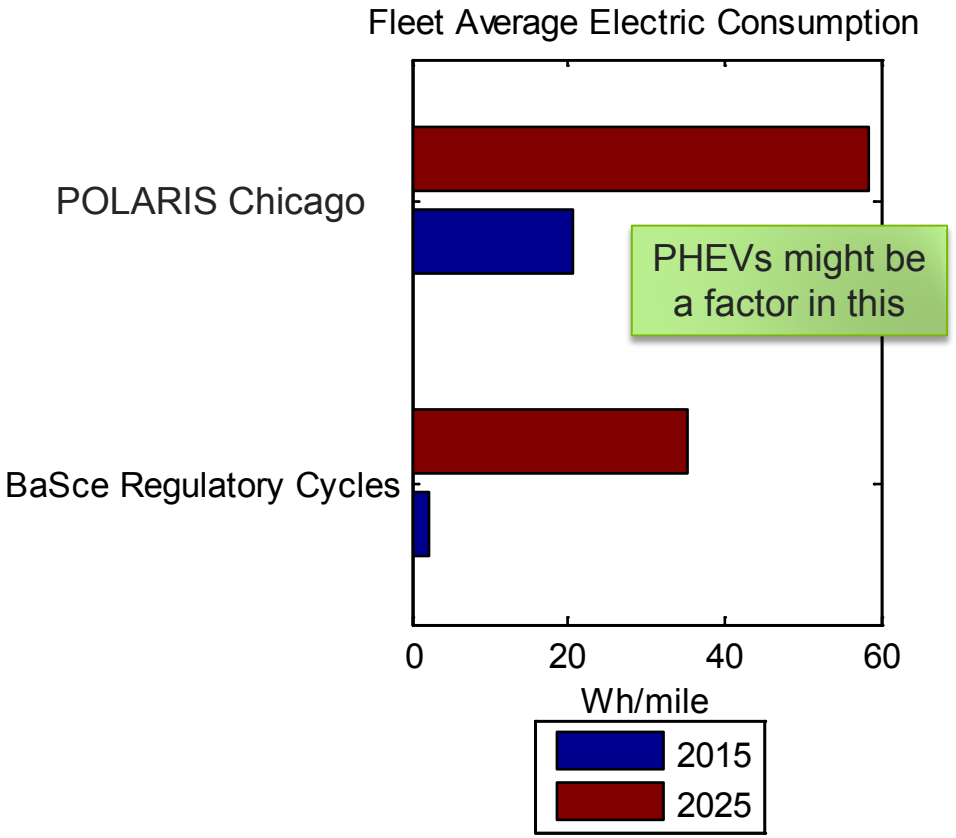
MA3T results from Zhenhong Lin (ORNL)

Technical Accomplishment

Fleet Average Fuel Economy & Electric consumption

Basce & RWDC Predict Doubling of Fuel Economy. RWDC Shows Higher Electric Consumption

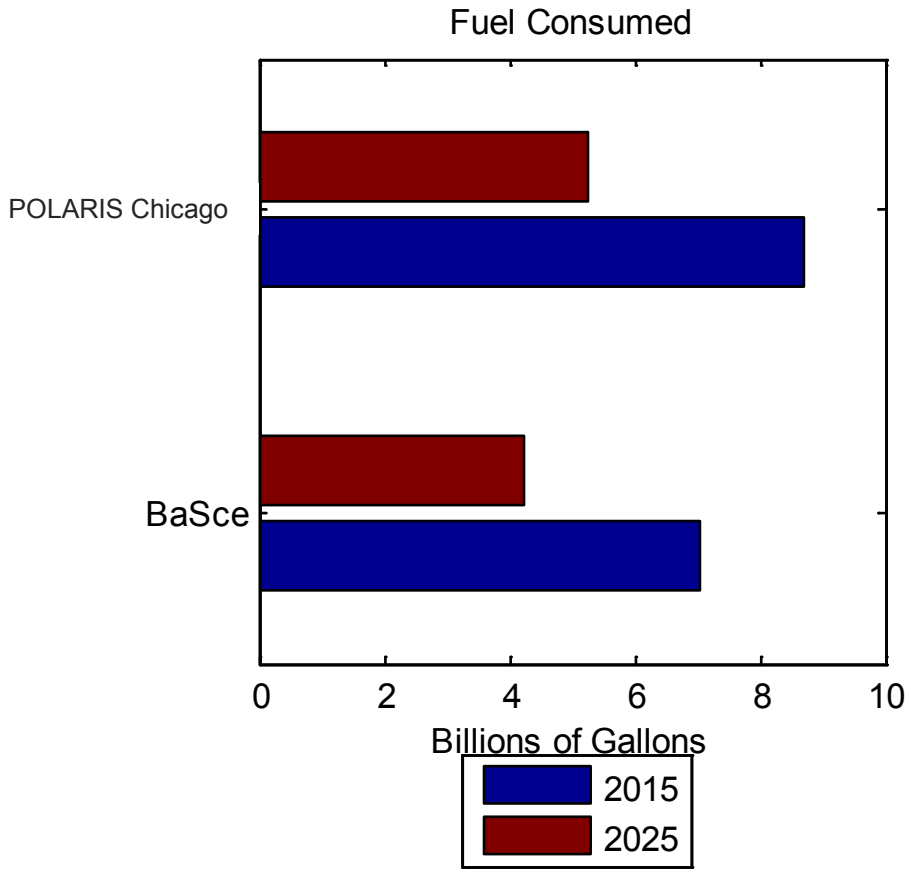


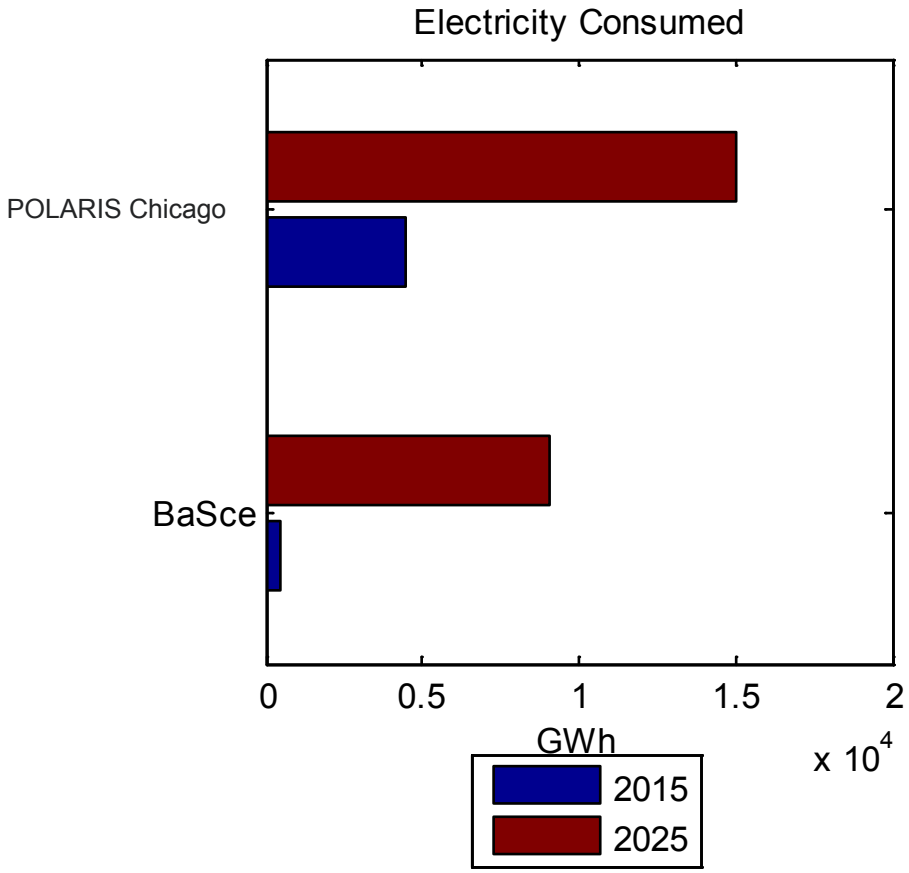


Technical Accomplishment

Cumulative Fuel & Electric Consumption

Basce & RWDC predicts similar decrease in fuel consumption
Electric consumption will increase.





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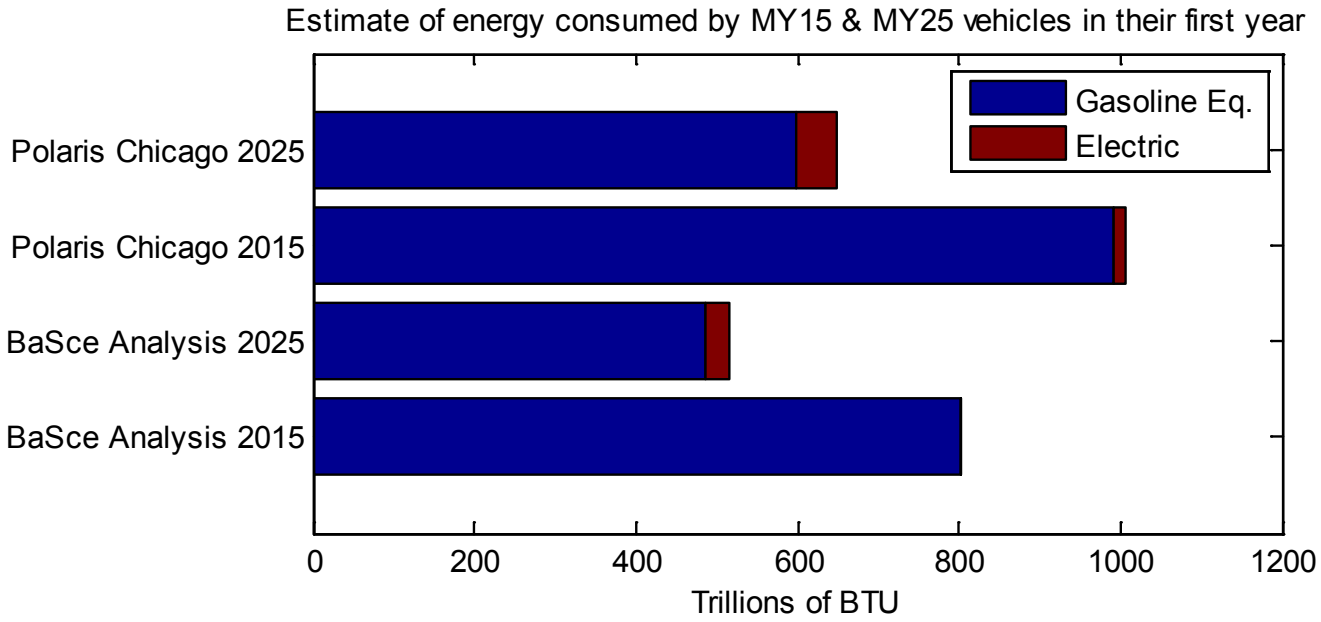
Technical Accomplishment

Overall Energy Consumption

Basce & RWDC predicts similar decrease in energy consumption



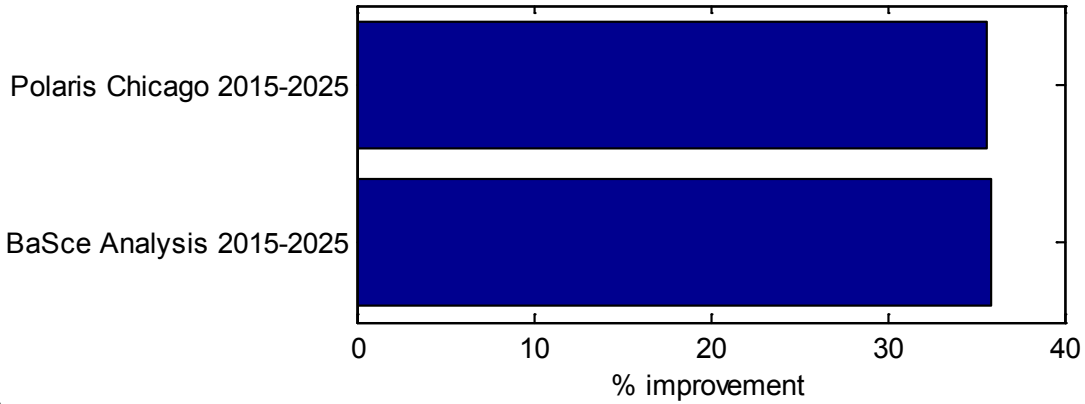
Magnitude of energy consumption varies significantly between the estimates done in BaSce (using Combined 2 cycle procedure) and Chicago cycles from Polaris.

- Chicago cycles consume more energy.
- Different testing conditions (UF, CD+CS tests)

Technical Accomplishment

Percentage Reduction in Energy Consumption

BaSce & Polaris Chicago cycle analysis predict similar percentage improvement in energy consumption



Why do they match so well?

- In the time period considered, total energy consumption is heavily influenced by conventional vehicles. Differences from other vehicles is small in comparison
- Major technological improvements considered in this study have similar impacts on real world cycles and regulatory cycles.
  - Engine efficiency changes
  - Light weighting
  - New transmissions
  - Better aerodynamics

Collaboration & Coordination with Other Institutions

- Utilized other DOE funded activities (BaSce) for vehicle assumptions
- Integrated Autonomie & POLARIS (a tool developed with DOT funding)
- Used market penetration data from MA3T (ORNL)
- Worked with Argonne's System Analysis group on reviewing the process to expand powertrain evaluations to regional/national fleet level estimates

Next Steps

- Assess impact of multiple market penetration scenario
- Evaluate technologies that can have a larger impact in real world driving (eg. micro hybrids, waste heat recovery systems)
- Include cost and GHG impact
- Evaluate type of driving cycles, locations (i.e., suburbs vs city) favorable to specific technologies
- Utilize process to quantify advanced technologies off-cycle credits

VTO Technology Benefits Summary

- The percentage improvement predictions of VTO technologies on standard cycles is valid for a wider set of driving conditions
- 40% reduction in energy consumption can be expected when MY25 vehicles are compared against MY15 vehicles.
- The magnitude of the energy consumed in 2015 and 2025 varies when we consider aggressive city cycles as in case of Chicago.

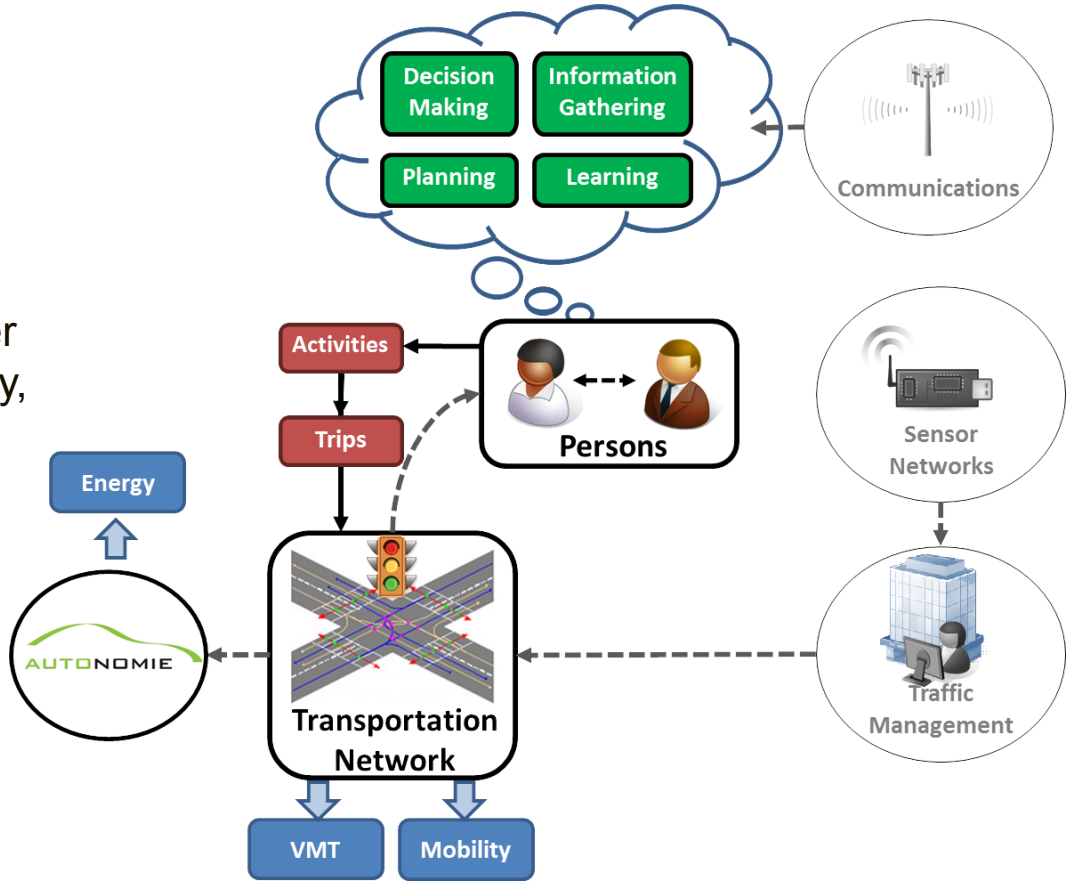
TECHNICAL BACKUP SLIDES

POLARIS

Transportation Systems Simulation Tool

- Developed at Argonne with DOT funding to model ITS
- **Integrated tool**: demand + traffic flow in one tool
- **Agent-based**: each traveler takes decision about activity, schedule, route and mode choice
- Suited for ITS & CAVs: travelers can change plans during trip

POLARIS



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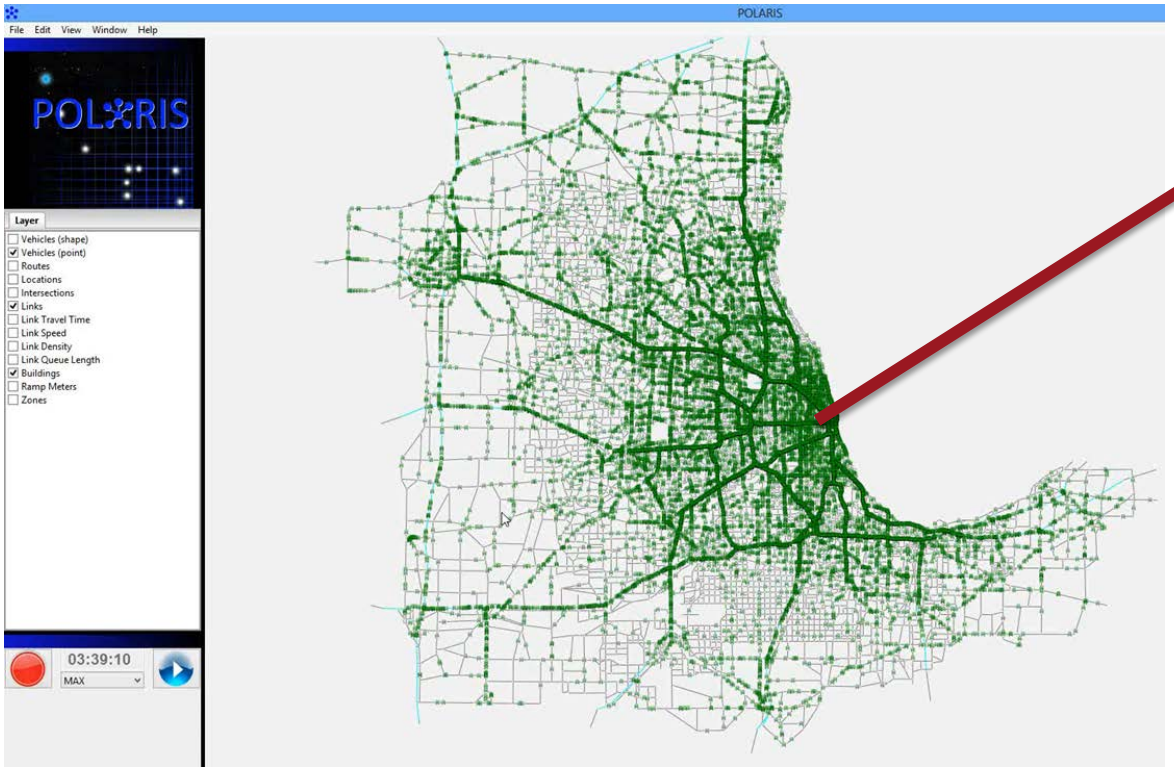
Approach

Area of POLARIS Chicago Regional Model Selected



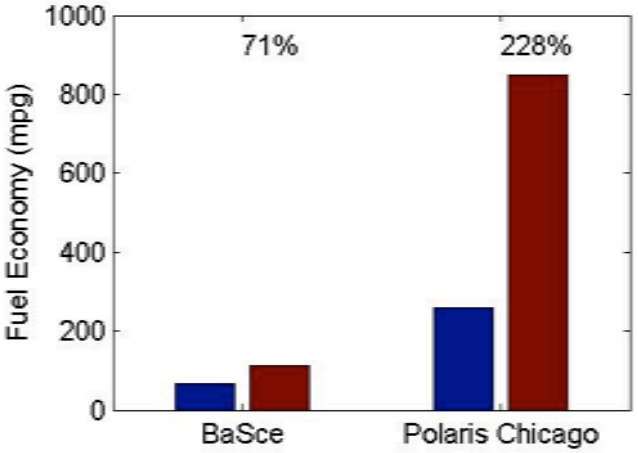
Full scale model: 10M Travelers, 27M Trips

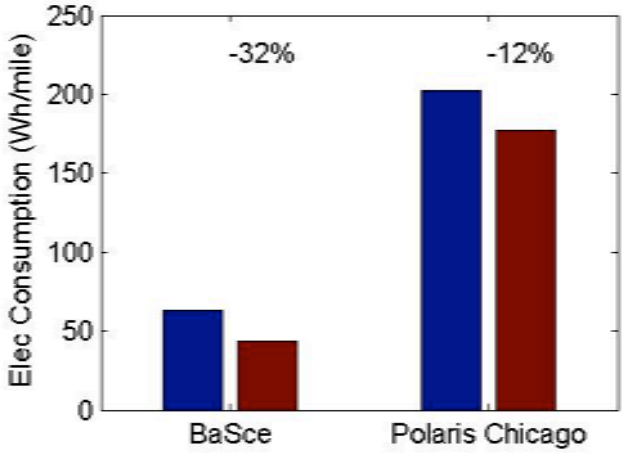
Study area: Chicago downtown [5000 links, 3000 intersections, 400k travelers]

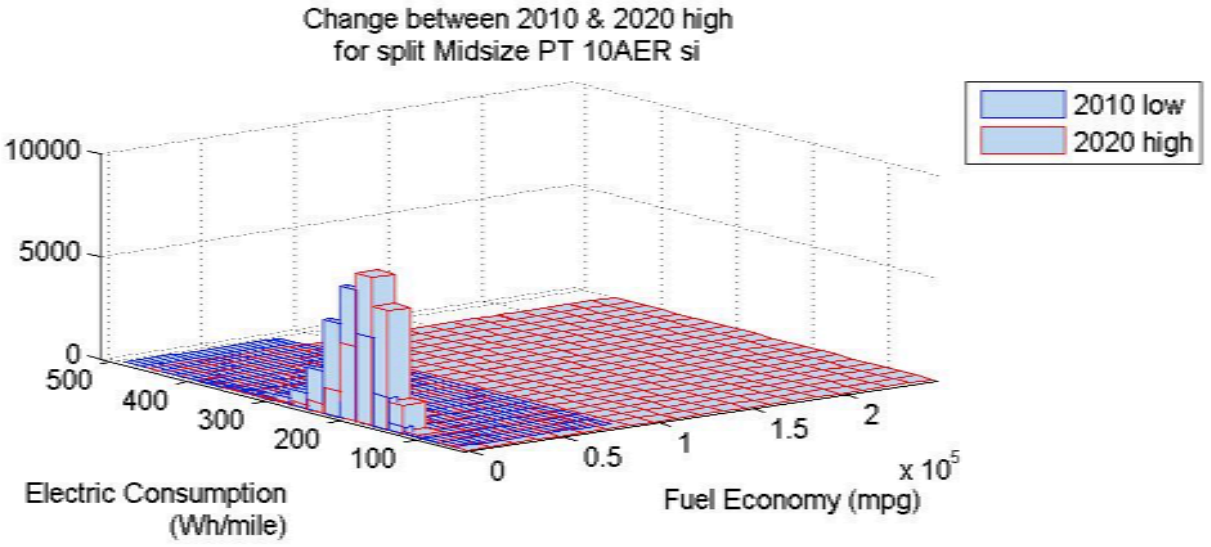
Sample

Technical Accomplishment

Power Split PHEV 10 Miles AER Midsize Results

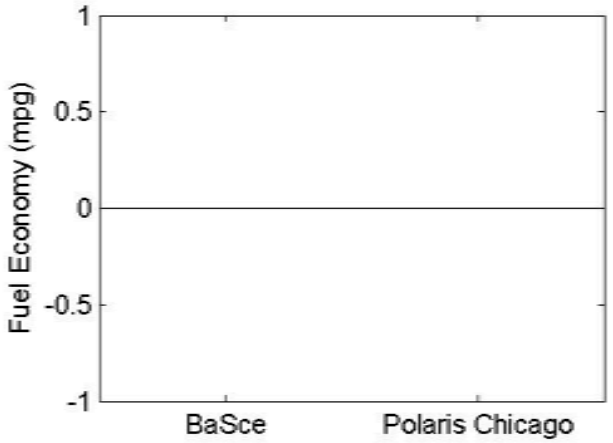


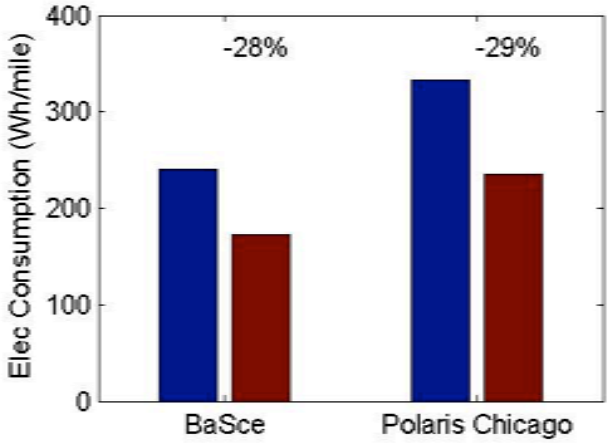


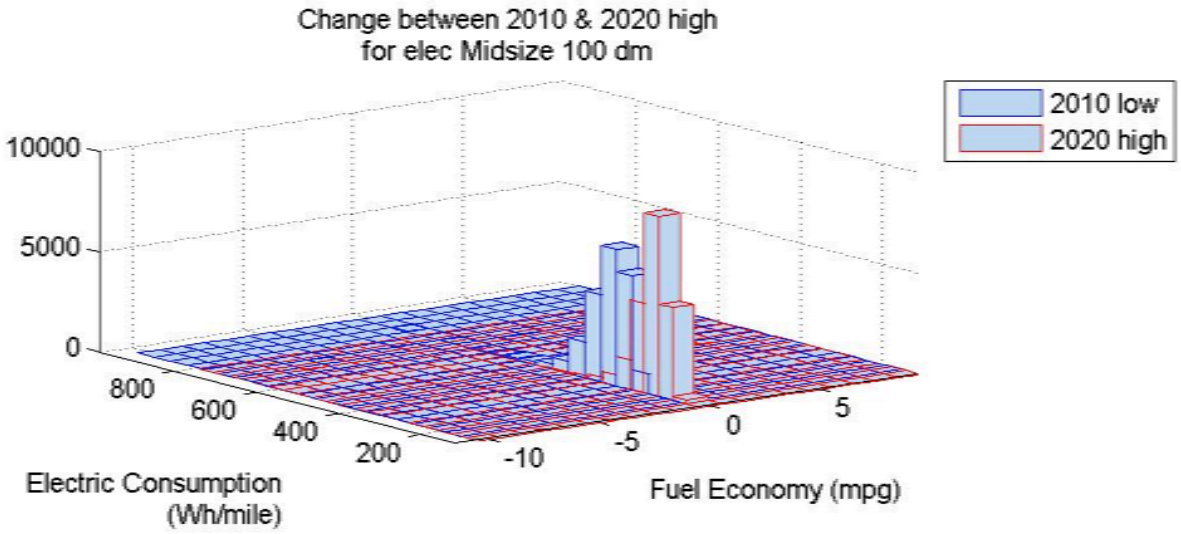


Technical Accomplishment

BEV 100 Miles AER Midsize Results







Technical Accomplishments

New Vehicles Miles Travelled

Based on NHTSA household survey

- Average distance driven by new vehicles in the first year
  - Cars – 13852 miles
  - Light Trucks – 15300 miles

- When combined with the sales data, it gives the distance travelled by the new vehicles
  - 216 billion miles in 2015
  - 256 billion miles in 2025